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FOREST RESEARCH NOTES

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FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA

BERKELEY

Research Note No. 17 June 10, 1937

AN ANALYSIS OF SELECTIVE CUTTING ON A SAMPLE PLOT OF VIRGIN REDWOOD TIMBER IN HUMBOLDT COUNTY, CALIFORNIA[1]

Description of Study

The study herein outlined was suggested by the Redwood Lumber Code Authority in 1934 to test the practicability of tree-selection cutting in a dense stand of virgin redwood. An area of approximately 79 acres was surveyed and cruised. Redwood trees 36 inches and larger in diameter at breast height were individually recorded by stump diameter, merchantable height, and number of surface-clear logs, and all those having 3 or more clear logs were designated for cutting. Trees with less than 3 clear logs were to be left standing. Intermixed Douglas fir and white fir trees were tallied but not any of these species were to be cut. Likewise, all redwood trees smaller than 36 inches in diameter were to be left, irrespective of the proportion of clear length. The original stand per acre by species, marked and not marked for cutting, is summarized in table 1.

The study plot was logged in 1935, most of it with tractors and arches. Time studies were made of felling, bucking, peeling, yarding, and loading. Carload tallies were made of the logs on each car so that the effect of log size on load volume could be analyzed and load cost prorated properly to logs of different diameters.

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[1] By M. R. Brundage, Associate Forester, Section of Forest Products, California Forest and Range Experiment Station, U. S. Forest Service. Computation of the lumber selling values and margins as related to logs, trees, and cutting limits was done largely by T. J. Orr, Jr., Section of Forest Products. Logging cost data are from woods studies by H. L. Person and Wm. Hallin, Section of Redwood Management. Cooperators in the project were the Dolbeer and Carson Lumber Company, the Experiment Station, and the Division of Timber Management, California Region, U. S. Forest Service.

Table 1.- Original Stand on Selective-cutting Sample Plot
Average Acre

Species	Tree diameter 36 in. d.b.h. and larger		12 to 36 inches	
	Trees	Volume gross 1/ scale	Trees	Volume gross scale
	Number	Feet b.m.	Number	Feet b.m.
	TOTAL ESTIMATED STAND PER ACRE			
Redwood	15.4	198,700	15.8	5,500
Douglas fir	5.7	22,500	7.1	6,600
White fir	2.5	7,300	13.8	12,600
All species	23.6	228,500	36.7	24,700
	REDWOOD TREES MARKED FOR CUTTING			
Redwood	8.4	154,000	-	-
	NOT MARKED FOR CUTTING			
Redwood	7.0	44,700	(See above)	
D. & W. fir	8.2	29,800		
All species	15.2	74,500	36.7	24,700

SUMMARY, AVERAGE ACRE, TREES 12 INCHES AND LARGER

	Marked to cut	Not marked	Total
Number of trees per acre	8.4	51.9	60.3
Volume gross scale	154,000 ft.b.m.	99,200 ft. b.m.	253,200 ft.b.m.
Volume Humboldt scale logged 2/	(82,993)	-	(82,993)

1/ Gross Spaulding scale to 18-inch top diameters.

2/ Humboldt scale logged per acre was about 54 percent of the gross estimated volume of the 8.4 redwood trees marked to cut. If this ratio is applied to the total volume, the estimated original stand in terms of net Humboldt scale was 136,728 feet b.m. per acre.

Logs were graded in the standing trees and again after felling, using a tentative log grade classification which has been described in Research Note No. 8, issued by the Experiment Station on March 10, 1936. Each log was numbered with the tree number and the position of the log in the tree, for identification at the mill.

A mill-study crew observed the logs at the time of sawing, scaling and grading on the deck, timing the headsaw, numbering the boards for identification on the green chain and tallying the lumber by dimensions and green lumber grades for each log individually.

Analysis of Data

A comparatively small sample of the study-plot logs was observed during the mill study. Of 583 logs tallied, about 140 were from areas adjacent to the plot, leaving 443 originating within the surveyed plot boundaries. Lumber grade production was compiled and curved on the basis of both the original pre-study log grade specifications and on a revised three-grade basis formulated later after examination of the log-description records made in the woods before peeling and on the mill deck after peeling. The revised log grades based on appearance before peeling were described, and the lumber grade production, overrun, and comparative log values were published in Experiment Station Research Note No. 12 on October 2, 1936. As explained in that Note, the revised log grades are not fully satisfactory but are probably as good as any that can be formulated from the small amount of data now available. Grade 3, in particular, does not represent the average of all the lower grade logs on the study plot but only the best of the low-grade logs which were utilized at the time of the study. After further studies are made, it will probably be found that at least one more log grade should be defined in addition to revision of the specifications for the upper grades.

Rough green lumber selling prices as of May, 1936, were used in computing log values. Quantity discounts were deducted according to the customary practice of the industry for cargo shipments. The prices as finally adjusted represent the values F.O.B. mill dock. Operating costs were also calculated on the 1936 scale of wages and costs of supplies. As indicated in table 4, the total cost of production, including every item except stumpage and interest on bonded indebtedness, amounted to $20.00 per M B.M. for a cut of 116 M B.M. per acre.

Tree values for 102 trees of various sizes, measured after felling and bucking, were reconstructed by application of log-grade values. Costs for the same trees were also reconstructed from curved log costs.

Log Costs and Values

The costs of logging and milling redwood logs of different sizes and the rough green lumber selling values F.O.B. mill by log grades are shown in table 2 and chart 1. These costs do not include felling, which varies with tree size, certain fixed costs per M B.M., or fixed acre costs (railroad and tractor road construction, and rigging up at landings), as explained in the footnotes below table 2. The margins, therefore, represent only the differences between these minimum handling costs and the lumber selling values of the various sizes of logs. The smallest size which paid back, on the average, both the minimum handling costs and a woods and mill overhead cost of $2.00 per M B.M., was a 21-inch, Grade-3 log. This is indicated in chart 1 by the first dotted line above the OPERATING COSTS curve. The second dotted line adds $1.47 per M B.M. to cover fixed costs per acre for the experimental selection cut of approximately 83 M B.M. per acre. The smallest sizes returning enough value to cover both fixed-per-M and fixed-acre costs, in addition to handling costs were:

Log Grade 2 - 22½ inches
Log Grade 3 - 27 inches

The dotted curves in the lower part of chart 1 show woods and mill costs separately. The BUCKING TO CARGO curve is plotted on the sums of the costs represented by the two lower curves. (See columns 3, 4, and 5 in table 2 for the costs represented graphically by these curves.)

Tree Costs and Values

Results of reconstructing the costs and lumber selling values for different sizes of redwood trees from log costs and values, plus felling costs, are shown in table 3 and chart 2. The average tree 30 inches in diameter at 20 feet from the base paid back $0.44 per M B.M. above these minimum handling costs. Adding the $2.00 overhead charge, the marginal tree was about 34 inches in diameter at 20 feet from the base. The minimum size which paid back all costs (except stumpage) was about 37 inches in diameter at 20 feet above the base. These two points are shown by the intersections of the two dotted lines above the FELLING-TO-CARGO curve, as explained above in connection with log chart 1.

The tree values in table 3 and chart 2 represent the average values of the woods-run of each tree size and not the values of the selected trees containing 3 or more clear logs. It was possible to reconstruct the values on this basis from felled trees which had been originally designated as "leave" trees, and from log-grading standing trees. These values were computed so that the entire plot stand could be analyzed on a diameter-cutting-limit basis.

Cutting to Different Tree-diameter Limits

The estimated results of cutting all redwood trees on the study plot 30 inches and larger in diameter at 20 feet from the base, 35 inches and larger, 40 inches and larger, and so on by 10-inch intervals to 80 inches and larger, are summarized in table 4 and chart 3. The average margins were derived by deducting all operating costs, including fixed overhead and fixed acre expense, from the average green lumber selling values recovered. From this analysis, it is apparent that the maximum net return per M B.M. exclusive of stumpage for the entire tract would be secured by cutting only the redwood trees 70 inches in diameter and larger. The yield would be approximately 69 M B.M. lumber tally per acre and approximately 43 M B.M. Humboldt scale per acre in redwood trees 30 inches to 69 inches in diameter would be left standing for a second cutting cycle, in addition to 5.5 M B.M. per acre of redwood trees smaller than 30 inches at 20 feet above the base, and about 41.5 M B.M. of Douglas fir and white fir of all sizes.

Maximum margin per acre would come from cutting all redwood trees 35 inches and larger, but maximum profit per acre, after deducting a stumpage charge of $4.00 per M B.M., would come from cutting to a 40-inch tree diameter limit. Margins from other cutting limits may be read from table 4 and chart 3.

The possibilities of changing over to a sustained-yield system of management in redwood stands of the type studied appear to be very favorable from the financial angle according to the results of this analysis. Assuming a constant yearly cut of 40,000 M B.M. per annum, the yearly net income from cutting in stands similar to that on the study plot would be $66,800 more from cutting to a 70-inch limit than from cutting to a 30-inch limit. About twice the acreage would be cut-over each year, but this extra profit makes allowance for the complete annual write-off of the extra railroad and other development charges incident to logging the larger area. That such selective cutting is feasible from the operating standpoint has been amply demonstrated by the cooperator in this project and by other redwood loggers who have developed tractor logging in the region to a high degree of perfection in a few short years.

Table 2.- Operating costs, rough green lumber selling values, and margins for redwood logs of different grades and diameters. Costs and prices as of May, 1936.

Log diam. small end[1]	Operating costs, bucking to pond[2] per M B.M. Humboldt scale	Operating costs, bucking to pond[2] per M B.M. lumber tally	Sawmill costs[3]	Woods and mill costs[2] [3]	Green lumber selling values, average for[4] log grade 1	log grade 2	log grade 3	Margin for felling, other costs, and profit		
Inches		Per M B.M. green lumber tally								
20	$10.24	$9.17	$ 9.13	$18.30	$23.85	$21.20	$20.05	$ 5.55	$ 2.90	$ 1.75
25	9.13	8.29	9.04	17.33	24.74	21.77	20.40	7.41	4.44	3.07
30	8.31	7.69	8.97	16.66	25.67	22.60	20.85	9.01	5.94	4.19
35	7.74	7.33	8.91	16.24	26.80	23.75	21.35	10.56	7.51	5.11
40	7.27	7.06	8.86	15.92	28.31	25.35	21.95	12.39	9.43	6.03
45	6.84	6.86	8.81	15.67	30.00	26.62	22.60	14.33	10.95	6.93
50	6.44	6.62	8.76	15.38	31.32	27.67	23.38	15.94	12.29	8.00
55	6.16	6.45	8.74	15.19	32.45	28.45	24.18	17.23	13.26	8.99
60	5.94	6.30	8.70	15.00	33.35	29.12	24.98	18.35	14.12	9.98
65	5.84	6.25	8.75	15.00	34.05	29.75	25.65	19.05	14.75	10.65
70	5.81	6.27	8.95	15.22	34.70	30.25	26.30	19.48	15.03	11.08
75	5.83	6.33	9.15	15.48	35.20	30.75	26.85	19.72	15.27	11.37
80	6.33	6.91	9.45	16.36	35.58	31.22		19.22	14.86	
85	7.16	7.85	9.85	17.70	35.87	31.65		18.17	13.95	
90	7.19	7.93	10.16	18.09	36.14			18.05		

[1] Average log diameter inside bark.

[2] Costs include peeling, bucking, yarding, loading, R.R. transportation, unloading, booming, and rafting to pond. Not included,- felling, R.R. construction, tractor road construction, general overhead, stumpage.

[3] Sawing, edging, green lumber resaw, trimming, green chain, green grading, and green lumber handling costs. Not included,- kiln and air drying, surfacing, remanufacture, and plant overhead.

[4] Based on rough green lumber selling prices as of May, 1936, F.O.B. mill.

REDWOOD LOGS

OPERATING COSTS AND REALIZATION VALUES
AS RELATED TO LOG DIAMETER AND LOG GRADE

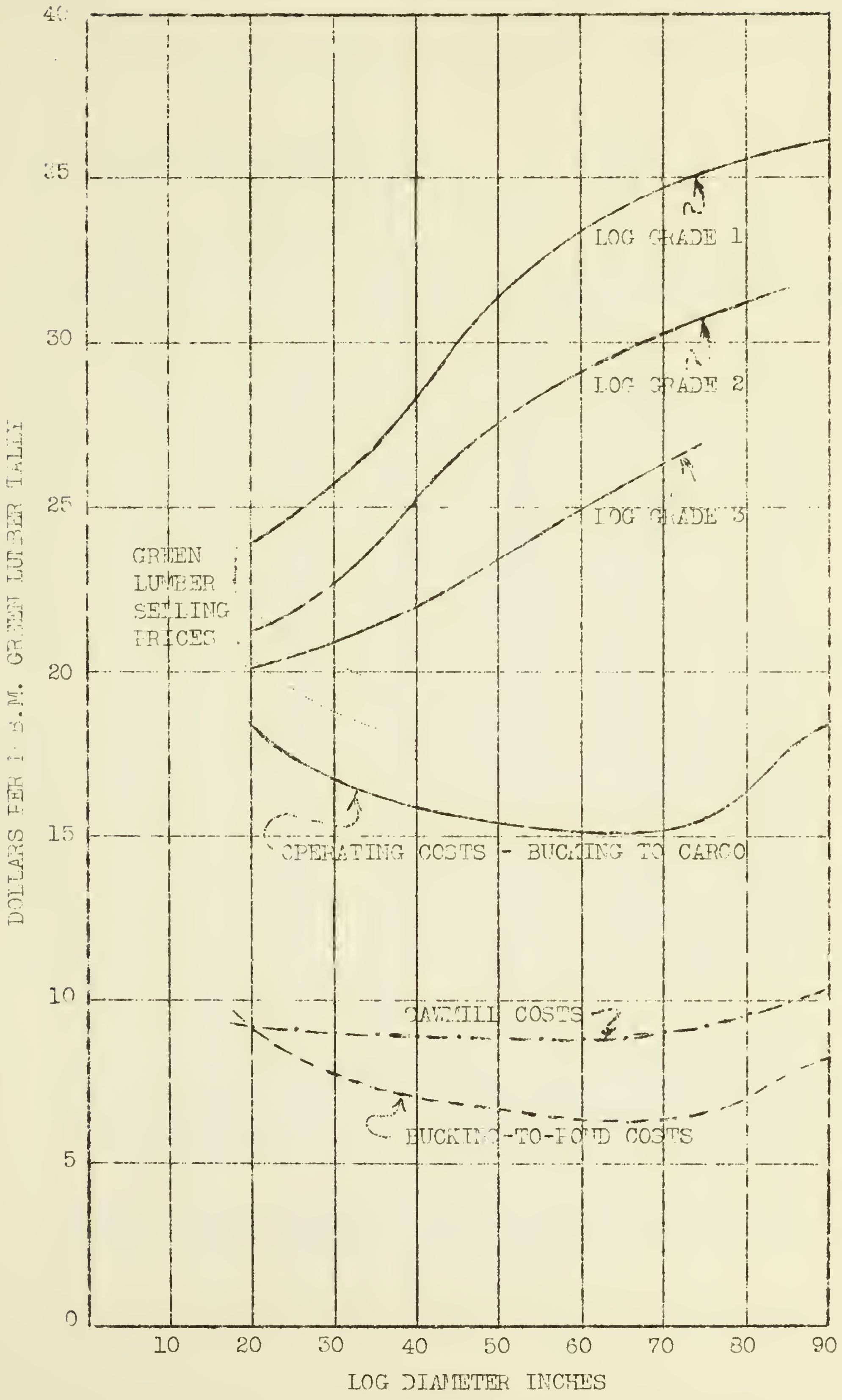

Chart 1.

Table 3.- Volumes, operating costs, selling values, and margins for average redwood trees of different diameters logged from a medium-quality stand in Humboldt County; 1936 costs and green lumber selling prices.

Tree dia. [1/]	Average tree green lumber tally	Operating costs felling to pond [2/]		Sawmill costs [3/]	Woods and mill costs [2/] [3/]	Average selling value [4/]	Margin for other costs and profits
		per M B.M. Humboldt scale	per M B.M. lumber tally				
Inches	Feet b.m.			Per M B.M. green lumber tally			
30	1200	$11.66	$10.38	$9.12	$19.50	$19.94	$ 0.44
31	1280	11.44	10.24	9.10	19.34	20.22	0.88
32	1360	11.24	10.11	9.09	19.20	20.50	1.30
33	1440	11.07	9.98	9.07	19.05	20.78	1.73
34	1530	10.88	9.85	9.06	18.91	21.09	2.18
35	1620	10.69	9.72	9.04	18.76	21.45	2.67
40	2128	9.88	9.15	8.98	18.13	22.81	4.68
45	3152	9.17	8.64	8.93	17.57	24.10	6.53
50	4318	8.65	8.29	8.89	17.18	25.32	8.14
55	5262	8.28	8.07	8.86	16.93	26.37	9.44
60	6808	7.97	7.90	8.83	16.73	27.45	10.72
65	7931	7.69	7.76	8.80	16.56	28.46	11.90
70	9165	7.47	7.65	8.78	16.43	29.40	12.97
75	10303	7.26	7.54	8.77	16.31	30.24	13.93
80	11625	7.12	7.47	8.78	16.25	30.94	14.69
85	13220	7.04	7.46	8.84	16.30	31.46	15.16
90	14830	7.04	7.50	8.93	16.43	31.87	15.44
95	16885	7.05	7.56	9.04	16.60	32.23	15.63
100	18681	7.12	7.68	9.17	16.85	32.56	15.71
105	20765	7.22	7.82	9.32	17.14	32.87	15.73
110	22908	7.33	7.97	9.49	17.46	33.17	15.71
115	25954	7.49	8.17	9.67	17.84	33.35	15.51

[1/] Outside the bark at 20 feet from the base.

[2/] Costs include felling, peeling, bucking, yarding, loading, R.R. transportation, unloading, booming and rafting to pond. Not included,- railroad construction, tractor roads, taxes, general overhead, stumpage, and other costs independent of tree sizes cut.

[3/] Sawing, edging, green lumber resaw, trimming, green chain, green grading, and green lumber handling costs. Not included,- kiln and air drying, surfacing, and remanufacture.

[4/] Based on rough green lumber selling prices as of May 1936, F.O.B. mill.

REDWOOD TREES

OPERATING COSTS AND LUMBER VALUES
AS RELATED TO TREE SIZE

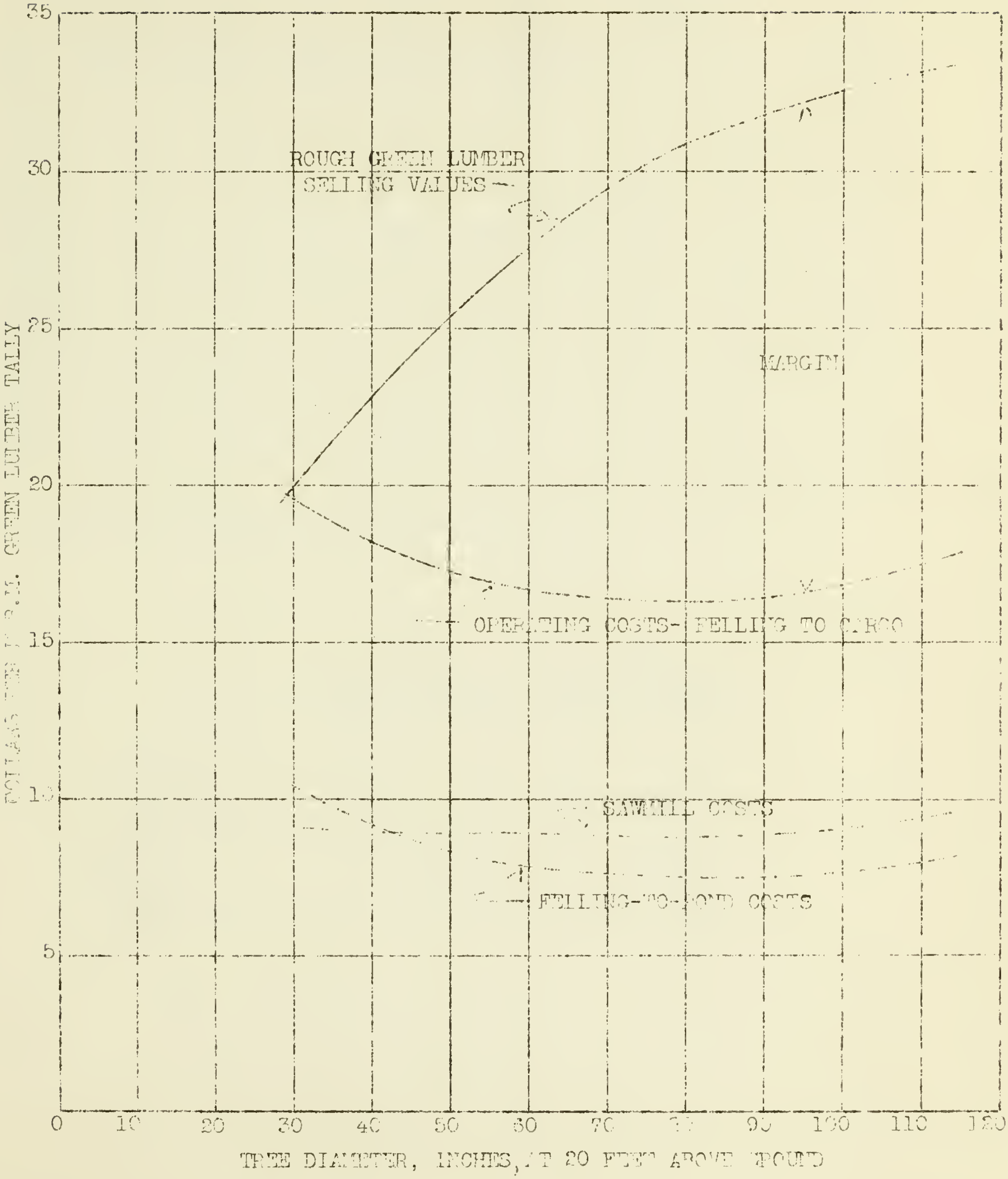

Chart 2

Table 4.- Results of cutting redwood trees to different minimum tree-diameter limits on the Humboldt study plot.

Tree sizes cut	Trees per acre cut	Approximate acre volume		Avg. total prod. costs	Avg. green lumber value	Margin for stumpage and profit		Profit per acre. $4.00 stumpage deducted
		1/ Cut	1/ Left			per	per	
Inches	No.	M B.M.	Humb.	Per M B.M. tally		M B.M.	acre	
80 and larger	3.1	56	60	$ 21.29	$ 32.33	$ 11.04	$ 573	$ 350
70 and larger	4.8	73	43	20.56	31.79	11.23	772	479
60 and larger	7.0	90	26	20.16	31.11	10.95	940	579
50 and larger	9.5	103	13	20.00	30.46	10.46	1039	625
40 and larger	12.0	112	4	19.97	29.93	9.96	1079	631
35 and larger	14.1	114	2	19.98	29.71	9.73	1083	624
30 and larger	15.5	116	0	20.00	29.56	9.56	1082	616

1/ Volume of redwood trees 30 inches and larger in diameter outside bark at 20 feet above the base.
To the volume left, add the following volumes per acre:

Species	30 inches and smaller		30 inches and larger	
	Trees	Volume	Trees	Volume
Redwood	15.8	5.5	-	-
Douglas fir	7.1	6.6	5.7	16.9
White fir	13.8	12.6	2.5	5.5
Totals	36.7	24.7	8.2	22.3
		M B.M.		M B.M.

RESULTS OF CUTTING REDWOOD TREES TO DIFFERENT MINIMUM TREE-DIAMETER LIMITS ON THE HUMBOLDT STUDY PLOT

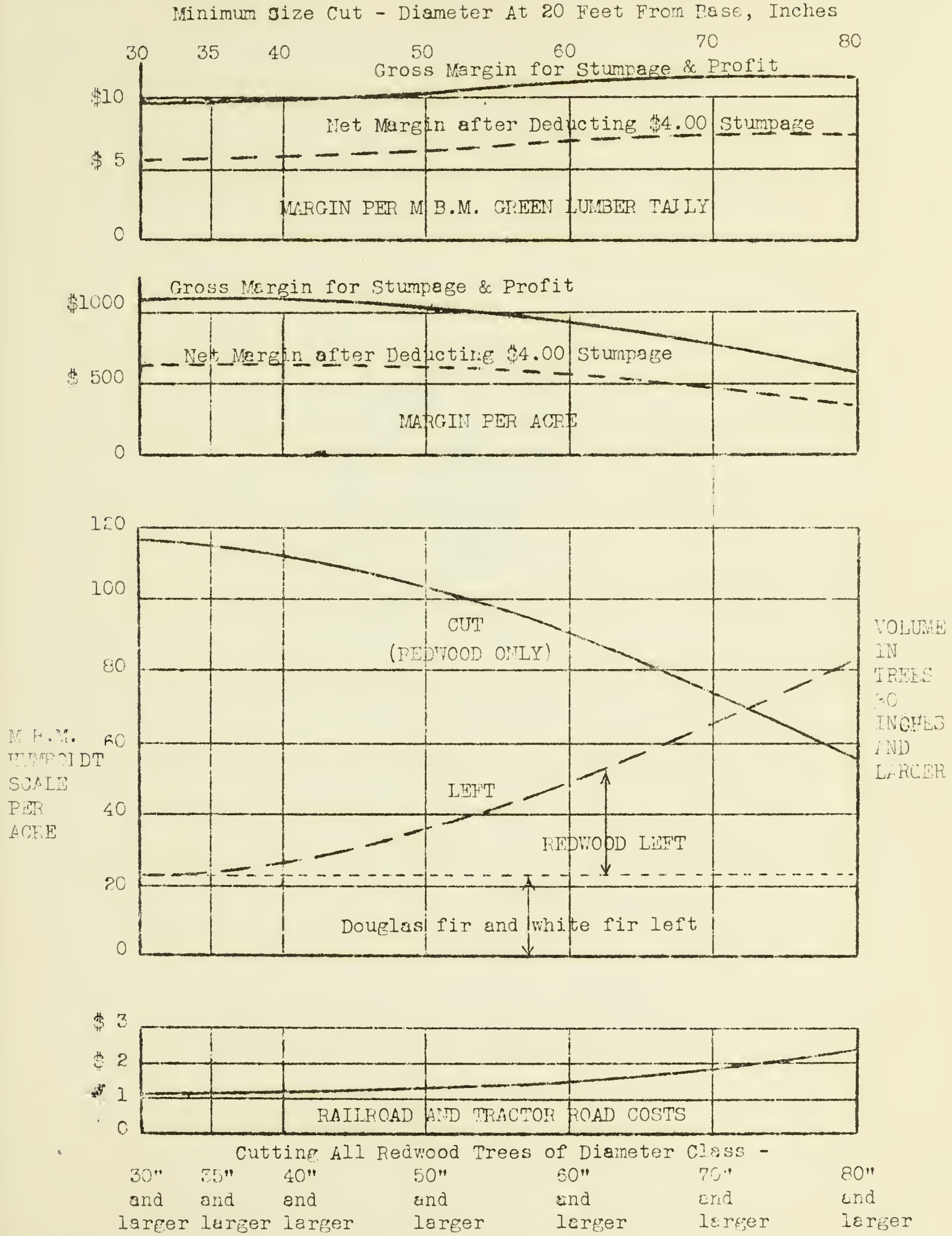

Chart 3

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